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IMPACT OF BUSINESS SIZE ON INNOVATION PROCESS AND PRODUCTIVITY IN GEORGIA

DAVIT SIKHARULIDZE [1], SHOTA SHABURISHVILI [2], LEILA KADAGISHVILI [3], TEA MUNJISHVILI [4], RUSUDAN MAISURADZE [5] and KHATIA UDESIANI [6]

[1, 2, 4] Doctor of Economics, Associate Professor, Ivane Javakhishvili Tbilisi State University. Tbilisi, Georgia.
[3] Doctor of Economics, Assistant Professor, Ivane Javakhishvili Tbilisi State University. Tbilisi, Georgia.
[5, 6] Student of Doctoral Program of Business Administration, Ivane Javakhishvili Tbilisi State University. Tbilisi, Georgia.
Email: [1]davit.sikharulidze@tsu.ge, [2]shota.shaburishvili@tsu.ge, [3]leila.kadagishvili@tsu.ge, [4]tea.munjishvili@tsu.ge, [5]rusudan.maisuradze@tsu.ge, [6]Khatia.udesiani@gmail.com
ORCID ID: [1]0000-0003-1738-9828, [2]0000-0001-8091-7684, [3]0000-0002-2811-6000, [4]0000-0001-8578-4470, [5]0009-0000-7929-9401, [6]0000-0001-5788-1214

Abstract

In contemporary times, there is a widespread and continuous technological transformation driven by the scientific-technical revolution, affecting all countries. Consequently, the focus of a nation's development has shifted from a static, short-term, and resource-based business approach to more innovative, dynamic, and creative models. For Georgian companies seeking to establish themselves as competitive entities in the global business landscape, it is crucial to conduct a comprehensive analysis of technological environmental factors and integrate them into their international business strategies. One critical aspect in this direction is the empirical examination of the relationship between innovation processes and productivity at the micro-level. To achieve this, the study employs microdata provided by the World Bank and employs structural model known as the CDM model. This approach allows for an analysis of the impact of product/service and process innovations on the productivity of Georgian companies, considering their specific scale and size. The research proceeds in several stages. Firstly, it investigates the factors influencing research and development, followed by an analysis of the determinants of product/service and process innovation. Finally, the study identifies the overall impact of innovation on productivity. Notably, the results highlight significant causal connections between innovation and productivity concerning the size of the company. Surprisingly, the empirical research conducted on Georgian firms revealed unexpected outcomes. Specifically, it was found that research and development (R&D) exerted a statistically significant negative influence on innovation processes. Furthermore, the contribution of innovation to labor productivity was not statistically significant. However, on a positive note, the study demonstrated that investments in fixed capital and the number of employees had a favorable impact on labor productivity. In conclusion, the ongoing technological advancements driven by the scientific-technical revolution have led countries to shift their developmental focus towards innovation-oriented and dynamic business models. For Georgian companies aiming to thrive in the global business arena, it is essential to consider the relationship between innovation and productivity at the micro level. The study conducted using the CDM model and microdata from the World Bank revealed interesting insights, indicating the need for further investigation and exploration of these findings.

Keywords: Innovation, Productivity, Firm Size, Research and Development

JEL Classification Codes: M10, O12, O31

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1. INTRODUCTION

As acknowledged by economic theory, continuous growth in prosperity and the maintenance of high rates of economic development are unattainable without a concurrent improvement in productivity. Productivity stands as the pivotal factor that determines a country's capacity to elevate its standard of living (Krugman, 1990). Hence, it becomes evident that nations must increasingly rely on local innovations to act as a driving force for the advancement of their national economies.

The World Bank identifies several factors contributing to low productivity in Georgia, such as deficiencies in transportation, infrastructure, information and communication technologies, as well as gaps in public administration capacity. Additionally, limited access to funding sources and scarce entrepreneurial skills further compound the problem. Although there have been some improvements in transport links in recent years, lingering logistics gaps persist, leading to increased costs in both domestic and international trade (World Bank Group., 2018).

Table 1 presents the findings of a 2019 survey conducted by the World Bank on the frequency of innovative processes in firms. Out of the 578 firms surveyed, only 43% had introduced new products/services or made improvements to existing ones within the previous three years. A mere 17% of firms had introduced new or improved existing processes, while only 23% of firms had invested in research and development (R&D) efforts.

Table 1: Innovative processes in small, medium and large firms

	Small				Medium				Large			
	2019		2013		2019		2013		2019		2013	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
New Products/Services Introduced Over Last 3 Yrs												
Don't know (spontaneo	2	0.6	0	0	0	0	0	0	0	0	0	0
Yes	121	37.7	16	7	85	47	13	14.4	40	53.3	7	17.1
No	198	61.7	213	93	96	53	77	85.6	35	0.5	34	82.9
Total	321	100	229	100	181	100	90	100	75	53.8	41	100
New Products/Services Also New For Thr Establishment'S Main Market												
Don't know (spontaneo	1	0.8	0	0	2	2.4	0	0	0	0	0	0
Yes	80	66.1	12	75	57	67.1	13	100	28	70	6	85.7
No	40	33.1	4	25	26	30.6	0	0	12	30	1	14.3
Total	121	100	16	100	85	100	13	0	40	100	7	100
Process innovationa: During the last three years, has this establishment introduced any new or improved process? These include: methods of manufacturing products or offering services; logistics, delivery, or distribution methods for inputs, products, or services; or supporting activities for processes?												

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Don't know (spontaneo	2	0.6	4	1.7	1	0.6	0	0	0	0	0	0
Yes	44	13.7	14	6.1	29	16	9	10	24	32	8	19.5
No	275	85.7	211	92.1	151	83.4	81	90	51	68	33	80.5
Total	321	100	229	100	181	100	90	100	75	100	41	100
Over the last three years, did this establishment spend on research and development activities within the establishment?												
Don't know (spontaneo	0	0	0	0	0	0	0	0	1	1.3	0	0
Yes	25	7.8	6	2.6	31	17.1	5	5.6	25	33.3	7	17.1
No	296	92.2	223	97.4	150	82.9	85	94.4	49	65.3	34	82.9
Total	321	100	229	100	181	100	90	100	75	100	41	100

Table 1 presents an analysis of innovation processes in firms categorized by their size. As evident from the table, among the 246 firms that introduced new products/services or made improvements to existing ones within the previous three years, 50% are classified as small firms, 34.6% as medium firms, and 16% as large firms. Out of the 97 firms that implemented or improved processes during the same period, 45% are small firms, 30% are medium firms, and 24.7% are large firms. Furthermore, out of the 138 firms that allocated resources to research and development (R&D) activities, 37.7% are small, 40.6% are medium, and 22% are large firms.

Comparing the data from 2013, Table 1 also reveals that in 2019, a higher percentage of small, medium, and large firms engaged in the introduction of new products and services. Additionally, there was an increase in the number of firms implementing process innovations in 2019 compared to 2013. However, concerning expenditures on R&D, the growth in the number of active firms in this area was only marginal.

The aim of the research is to empirically study the impact of innovative processes in firms on productivity by the firm size for the first time in Georgia. This paper is organized as follows: in Section 2, we present literature analysis, In Section 3, we describe theoretical framework, detail the specification of the econometric model, the data and define the explanatory variables used in the various equations of the model. Section 4 is dedicated to the presentation and interpretation of the results. Conclusions are presented in Section 5.

2. LITERATURE REVIEW

The innovation process in a firm plays a vital role in determining its competitiveness, which, in turn, is influenced by the firm's productivity (Sikharulidze & Kikutadze, 2017). In recent years, numerous researchers have been interested in examining how a firm's innovation performance affects its productivity, focusing on the implementation of innovative policies and conducting econometric research. Internationally, there exists a wealth of empirical research in this area, investigating the impact of both product and process-related innovations on

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productivity (Griliches, Z, 1995). However, empirical studies exploring the effects of such innovations on productivity in Georgia are still lacking.

At the macro level, studies on economic growth have primarily addressed innovation-related issues, considering economic growth as an endogenous phenomenon (Romer, 1990) (Aghion, 1992); (Porter, 1985). These studies have established a growing interest in innovations and have linked the innovative component of production to the accumulation of knowledge within the concept of production function. The outcomes of innovative activities differ across firms, as some gain market power, while others may only experience marginal profit (Shaburishvili & Kadagishvili, 2018). The modern understanding of different forms of innovations, based on micro-level studies, enables the measurement of various types of innovative efforts undertaken by firms (Kadagishvili, 2018). Consequently, traditional measures, such as R&D expenditures and the number of patents, have been replaced by innovative components integrated into production and direct measures of production output (Sikharulidze, 2018).

In endogenous growth models, productivity improvement is partially attributed to expenditures on R&D with a focus on commercial feasibility. Innovation, resulting from R&D spending, can manifest in various forms, including new intermediary or consumer goods, leading to increased productivity or consumer utility (Shaburishvili & Gafrindashvili, 2017).

Since the early 1990s, scholars have shown an increasing interest in innovations, shifting the focus from the innovative component to the outcome of innovation implemented in the production process (Meskhia & Shaburishvili, 2015). This has allowed the combination of the production function of innovation-based productivity with the function of knowledge production. The CDM model, initially proposed by (Pakes, 1980) using patents as indicators of innovation, and later expanded by (Crepon B. D., 1998) to include innovation sales share, has become well-known. The CDM model examines the endogeneity of R&D and innovation results through a system of equations, with one equation capturing the intensity of innovation and the other reflecting the rate of productivity growth. To address the selectivity issue in the CDM model, where some firms are not engaged in R&D or innovation, researchers have utilized "tobit" models or Heckman's two-step approach. Moreover, the CDM structure allows for the use of binary and continuous data to analyze innovative components and/or outcomes.

The original CDM model, lacking productivity feedback to R&D, fails to consider that productive firms may have higher levels of innovation due to their capacity to finance innovative projects. To address this limitation, researchers have attempted to incorporate productivity into the equations governing innovation input or output. Such efforts have been documented in studies by Baum (2017), Raymond (2015), and Cainelli (2007).

Another extension of the CDM model incorporates time lags in the relationships among R&D, innovation, and productivity, while also considering sustainability in innovation and productivity. In such cases, accounting for unobserved heterogeneity is crucial to avoid erroneous conclusions about sustainability. Notably, studies have revealed a positive correlation between persistence and the intensity of innovation, with stronger associations observed among firms engaging in R&D (Peters, , 2009), operating in high-tech industries

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(Raymond, 2010), and pursuing radical innovation (Zhen N. , 2018).

Increased spending on research and development does not necessarily equate to innovation (Shaburishvili & Chania, 2017). This is especially true for small and medium-sized firms and can lead to inadequate assessments of the impact of innovation on productivity. To address this, subsequent studies have shifted their focus to the outcome of innovations rather than the components of innovation. According to some researchers, official R&D measures for SMEs may underestimate their innovation activities (Crepon B. D., 1998). Particularly, a study based on Italian firms enriched the specifications of the CDM model with time series, finding that process innovation significantly impacts productivity, and R&D is positively related to the introduction of a new product, with the likelihood of process innovation being directly related to investment in the company's fixed capital (Parisi, 2006).

Empirical Model

The empirical analysis relies on a modified version of the widely used structural model known as the CDM model, originally developed by Crepon, Duguet, and Mairesse (Crepon B. D., 1998). In this model, firm productivity is explained by innovations, which, in turn, are driven by investment in R&D. The standard CDM model comprises two equations related to R&D: one describes the innovation equation, and the other defines the production function. Different econometric models and explanatory variables are chosen for various studies. In our study, we mainly apply the Griffith model (Griffith, 2006). Although there is a significant difference in the set of explanatory variables used.

The model which will be used in our study can be formulated as follows. Let us assume that i = 1, …, N to index firms. Equation (1) represents the firm's latent (unobservable) propensity for innovatingg_i^*:

Where

$$g_i^* = \beta_0 x_{0i} + \varepsilon_{0i} \quad (1)$$

In this context, x_{0i} represents a vector of variables that determine the level of innovation effort, β_0 is the corresponding vector of coefficients, and ε_{0i} is the error term. Let's assume that g_i is an observable indicator variable. When this equation equals 1, it indicates that the firm is involved in R&D activities, otherwise, it equals 0. The firms invest in R&D activities (generally, in knowledge-making activities, so g_i=1) when g_i^*> exceeds a certain threshold, denoted by c, which represents the initial level. Accordingly, if $g_i^* \leq c$ then $g_i = 0$. The term g_i^* serves as a criterion for engaging in innovation activities, such as the expected return on investment in R&D.

If a firm is involved in innovative activities (i.e., if $g_i^* > c$), we can observe the current R&D expenditures of the firm i (i.e., the total innovation costs) denoted as r_i. The r_i variabe shows the latent intensity of the study for firm i. These two variables r_i and r_i^* are related to the second equation of the model:

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$$r_i = \begin{cases} r_i^* = \beta_i x_{1i} + \varepsilon_{1\,i} if g_i = 1 \\ 0 \; if g_i = 0 \end{cases} \quad (2)$$

We employ the generalized tobit model to estimate equations (1) and (2). Equation (2) represents the size or intensity of R&D activities, typically measured as expenditures on R&D per employee. However, in our study, we will use the total expenditure on innovation activities as a substitute. This choice is made due to the fact that only a relatively small number of Georgian firms are engaged in R&D activities.

We define x_{0i} and x_{1i} vectors of explanatory variables as

$$x_{0i} = l_i, f_i, m_i, I_i \text{ And } x_{1i} = f_i, m_i, c_i, o_i I_i$$

In the model, l_i represents firm size (number of employees in logarithmic form), f_i represents investments in machinery and equipment, m_i is a binary variable indicating involvement in the internationalization process (assigned 1 if the firm is primarily engaged in international business c_i is a vector of binary variables indicating different methods of innovative collaboration, o_i is a vector of binary variables representing various obstacles to innovation, and $I_i$represents industries. The third equation represents the production function of knowledge or innovation, linking the results of knowledge (innovation) with the factors influencing innovation.

$$t_i = a_K r_i^* + \beta_2 x_{2i} + \varepsilon_{2i} \quad (3)$$

where variable t_i is the outcome of innovation or the knowledge, which is an indicator of product and process innovation (binary variable), x_{2i} is a vector of explanatory variables, ε_{2i} is an error term. vector $x_{2i} = f_i, m_i, c_i, o_i I_i$.

In our model product and process innovation is a binary variable (Griffith, 2006)or sales of new products per employee can be used as its alternative (Loof, 2003). We use the third equation as the binary Probit model, hence the dependent binary variable is product P_i and processes Q_i innovation.

The last equation in this model is the production function (productivity equation) Cobb-Douglas technology function, where innovation is considered as an input along with labor and capital (Crepon B. D., 1998). Thus, the production function can be formulated as follows:

$$q_i = a_T t_i + \beta_3 x_{3i} + \varepsilon_{3i} \quad (4)$$

where q_i shows productivity, stands for the log of productivity (sales per employee), x_{3i} shows the vector of the standard control variables in the productivity analysis, ε_{3i} is an error term, which shows the normal distribution with zero mean and variation of σ_3^2. The vector of input variables is defined as $x_{3\,i} = k_i, l_i, P_i, Q_i, X_i$ where k_i is is the log of physical capital per employee ($k_i = logK_i$), P_i, $and\ Q_i$ predicted values of binary variable for products and processes obtained from the second stage. X_i is a binary variable, which shows whether a firm is engaged in export activities. The model as a whole can be summarized as follows. The first stage involves a two-equation model that demonstrates the decision-making process for two-step innovation. The first equation represents the firm's decision to engage in an innovation

The Seybold Report
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process or not, the second equation shows the size of the effort. These two equations are modeled in the generalized tobit model. On the second stage, the Probit model is used to measure product and process innovations.

1. Empirical Results

Table 2 illustrates the results of the generalized Tobit model for innovation investments the table shows that for Georgian firms access to international markets is not the factor that can have impact on R&D in innovations. This contradicts with a widely spread opinion that a firm involved in the internationalization process has sufficient resources to invest in innovation activities and therefore, it is more likely to engage in R&D. This is not surprising when we speak about Georgian firms as they mainly prefer the markets of the post-Soviet countries. The table shows that innovative cooperation with other firms, universities or research institutes does not have a significant impact on innovation activities in Georgia. Innovation activities are influenced by access to finance and the firm size. In addition, the larger the firm is, the greater its ability to spend on R&D.

Table 2: Innovation Investment Equation

Dependent variable: R&D engagement	Coefficient	Std. Error	Prob.
International competition	-0.05064	0.267148	0.8497
Log number of employees	-0.77352	0.625846	0.2165
Innovation cooperation	-1.2728*	0.555928	0.0221
Access to finance	0.225588*	0.118552	0.0571
Firms size	0.866542*	0.525304	0.099
C	0.630585	1.344251	0.639
Total observation	119		

Table 2 shows the regression coefficients of the knowledge production function. Binary Probit model is applied in the study to examine the factors that determine the product and process innovation. As we can see in the table, expenditures on R&D have a negative impact on both product and process innovations.

Table 3: Knowledge production function assessed by using the Probit model

	Dependent variable: product innovation		
Variables	Coefficient	Std. Error	Prob.
Research and development	-0.823950***	0.219671	0.0002
Collaboration in research and development	-0.265736	0.251384	0.2905
Investments	0.019533	0.118042	0.8686
International competition	0.262088*	0.117063	0.0252
Firm size	0.081619	0.182187	0.6542
Employment (in logarithms)	-0.259406	0.242056	0.2839
C	1.220244	0.644523	0.0583
Observation	244		
Pseudo-R^2	0.072065		
Log-likelihood	-156.6658		

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Collaboration in R&D is negatively correlated with product innovation; however, this variable is not statistically significant. Employment that is negatively related to product innovation is not statistically significant as well. Although investments in machinery, which includes the acquisition of new technologies, have a positive impact on product innovation, but the variable is not statistically significant. Thus, among the variables included in the study, R&D is the one that turned out to be statistically significant and it is negatively correlated with product innovation.

Table 4: Knowledge Production Function Assessed By Using the Probit Model

	Dependent variable: process innovation		
Variables	Coefficient	Std. Error	Prob.
Research and development	-0.69662	0.223346	0.0018
Collaboration in research and development	0.295600	0.253446	0.2435
Investments	0.022345	0.123948	0.8569
International competition	-0.054046	0.093606	0.5637
Firm size	-0.149282	0.231126	0.5184
Employment (in logarithms)	0.367010	0.333979	0.2718
C	0.050885	0.672003	0.9396
Observation	243		
Pseudo-R^2	0.098122		
Log-likelihood	-122.4906		

Table 4 shows knowledge production function assessed by using the Probit model. The results are almost the same what we obtained when studying the factors influencing product innovation. However, some small differences are also observed. As in the case of product innovation, the impact of R&D on process innovation is negative and statistically significant. Collaboration between firms in R&D has a positive impact on process innovation, but it is not statistically significant. Investments in the purchase of machinery have a positive impact on process innovation, but this variable is not statistically significant. International competition is not statistically significant as well, which means that involvement in the internationalization process does not encourage firms to improve business processes, which can be explained by the fact that most firms operating in Georgia choose markets where strict adherence to standards is not required and where competition is not focused on creating value. International competition has a negative impact on process innovation, but it is not statistically significant. The size of the firm, which also has a negative impact on process innovation, is not statistically significant either.

The Seybold REPORT
ISSN 1533-9211
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Table 5: Production Function (Productivity Equation)

Dependent variable: labor productivity	Coef.	Std. Err.	P>t
Product innovation	.0222608	.1762879	0.900
Investments (in log)	.226708	.0571103	0.000
Employment (in log)	.6623367	.1074711	0.000
Intermediate consumption (in log)	-.1957658	.111185	0.083
International competition	-.217801	.1218912	0.079
C	2.537589	.8843821	0.006
R^2	0.6298		
Observation	72		

Table 5 shows the assessment of production function (productivity equation). Here, productivity is assessed as the ratio of sales to the amount of the labor in logarithms. The table shows that product innovation has a positive impact on labor productivity, but this variable is not statistically significant. As expected, capital is a positive, statistically significant variable. The number of employees (in log) is also a statistically significant variable having a positive impact on labor productivity. Involvement in internationalization processes is negatively related to labor productivity, although this variable is not statistically significant. The assumption that export-oriented firms are more productive is rejected in Georgia. The share of intermediate consumption in the labor productivity process is not statistically significant.

Table 6: Production Function (Productivity Equation)

Dependent variable: labor productivity	Coef.	Std. Err.	P>t
Process innovation	-.0593014	.0670808	0.380
Investments (in logarithms)	.2279422	.056628	0.000
Employment (in logarithms)	.6673321	.1065826	0.000
Intermediate consumption (in logarithms)	-.2112931	.1115742	0.063
International competition	-.2007421	.1221668	0.105
C	2.760738	.8559241	0.002
Observation	72		
R^2	0,63		
Prob > F	0,0000		

Table 6 illustrates the impact of the factors affecting labor productivity. Among the variables applied, the interest of the research is focused on process innovation, which is negatively correlated with labor productivity. However, like in the case of product innovation, this variable is not statistically significant. Capital, investments in the purchase of new machinery, is statistically significant variable, which has a positive impact on labor productivity. The number of employees (in log) is also a statistically significant variable having a positive impact on labor productivity. The same cannot be said regarding intermediate consumption and international competition, which have negative but not statistically significant impact on labor productivity.

The Seybold REPORT

ISSN 1533-9211

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Table 7: Production function (productivity equation)

Dependent variable: labor productivity	Coef.	Std. Err.	P>t
Research and development	.0458797	.2078917	0.826
Investments (in logarithms)	.2277873	.0574052	0.000
Employment (in logarithms)	.659615	.1084833	0.000
Intermediate consumption (in logarithms)	-.1912582	.1135867	0.097
International competition	-.2190726	.1209693	0.075
C	2.461603	.9787942	0.014
Observation	72		
R^2	0,6300		
Prob > F	0,0000		

We also need to study the impact of expenditures on R&D on labor productivity. Table 7 shows that research and development expenditures have a positive impact on labor productivity, however, this variable is not statistically significant. Intermediate consumption and international competition, which are negatively related to labor productivity, are not statistically significant either. Fixed capital and labor have a positive and statistically significant impact on labor productivity.

2. CONCLUSION

Empirical research at the microeconomic level has shown significant relationships between innovation and productivity across firm size. The results of the study shows that in the case of Georgia, research and development efforts do not significantly affect entrepreneurial innovation. In particular, R&D has statistically significant negative correlation with product and process innovation. It was concluded that innovations in Georgia do not have a significant impact on productivity, which contradicts with a widely spread opinions. The growth of fixed capital and number of employees have statistically significant positive impact on productivity. This is confirmed by the results reflected in the Global Competitiveness Reports, according to which Georgia is in the "efficiency-oriented stage" of economic development. Based on the above, we can assume that the country should move from investment- to productivity-oriented proactive policy.

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Apandix

Variable Definitions

R&D engagement:	Dummy variable that takes value 1 if Over the last three years this establishment spend on research and development activities within the establishment
Product innovation	Dummy, 1 if establishment During the last three years introduced new or improved products or services
Process innovation	Dummy, 1 if establishment during the last three years, has introduced any new or improved process
Labor productivity	Real sales per employee, in logs.
Investment intensity	Investment in machinery per employee, in logs
Age	firm's age (in years)
Size classes	The Georgia Enterprise Surveys was based on the following size stratification: small (5 to 19 employees), medium (20 to 99 employees), and large (100 or more employees)
Intermediate consumption	Total annual cost of raw materials and intermediate goods used in production
Log number of employees	Natural log of the number of employees
International competition	Dummy, 1 if the firm's most important market is international market.